Metal & Electronics: Ink Jets as Manufacturing Tools

Cleaner Technology and Energy Efficiency: Structuring a Competitive Advantage

Office of Technical Assistance & Technology

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Boxborough, Massachusetts

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FUJIFILM Dimatix

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Metal & Electronics: Ink Jets as Manufacturing Tools

- Advantages for Manufacturing with Ink Jets
- Jetting Functional Fluids in the Lab
- Status of Ink Jets in Manufacturing
- New Technology for Development and Manufacturing

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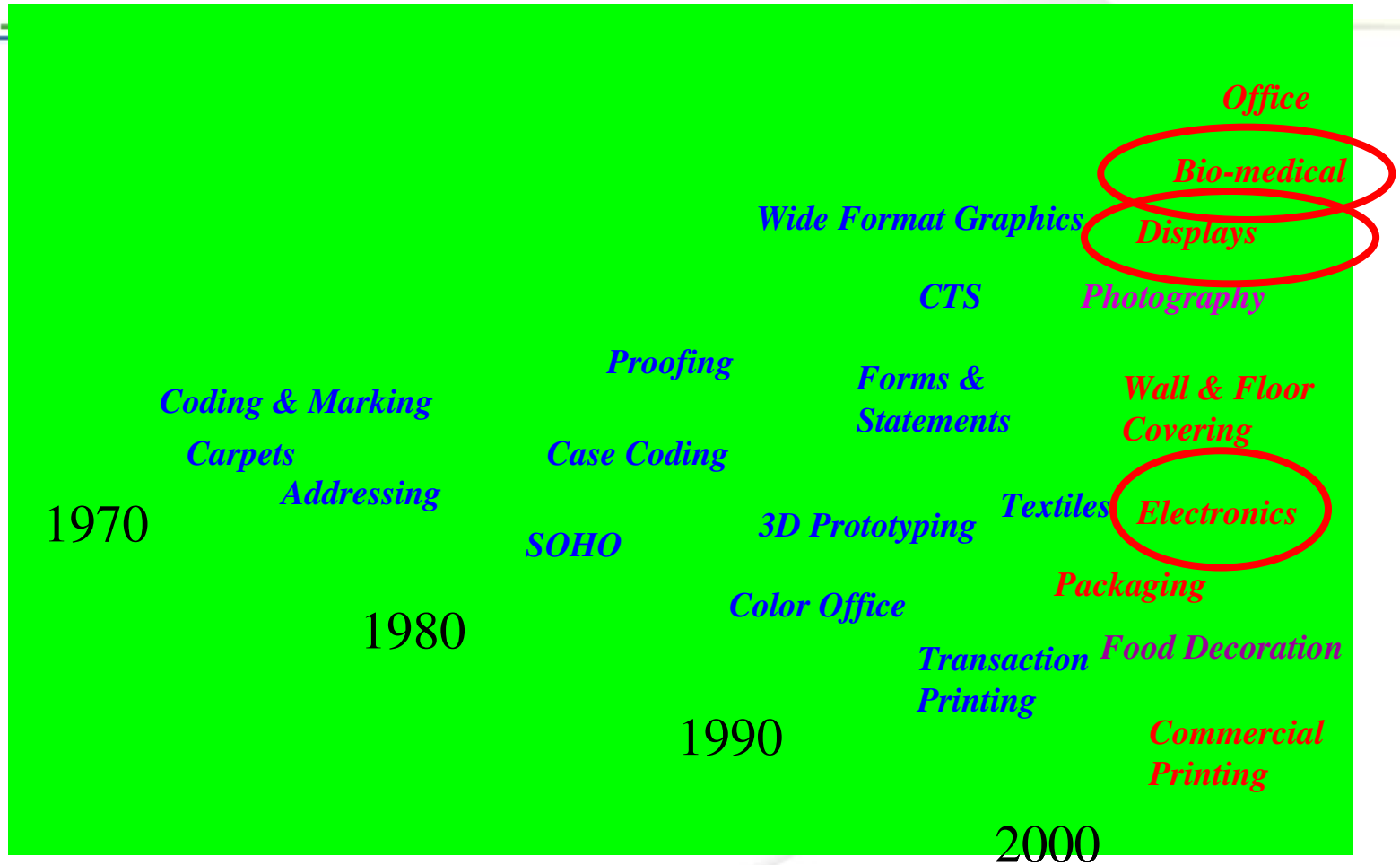
Ink Jet Market Perspective



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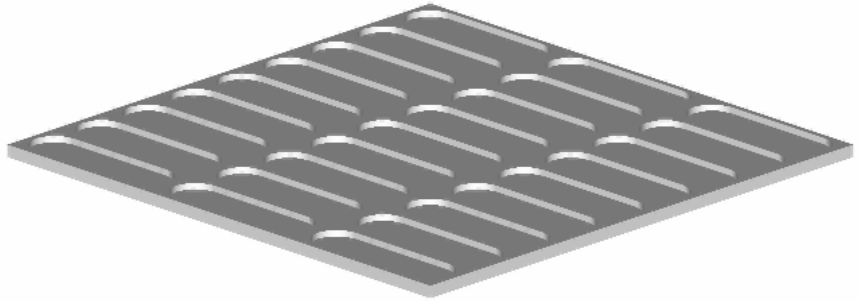
Advantages of Ink Jets in precision Fabrication

- Ink jet is non-contact digital printing
  - Consistent drop volume
  - Accurate drop placement
- Additive = does not waste expensive materials
- Special fluids formulated for each application
- Deposition system is ink jet, fluid, printer and software



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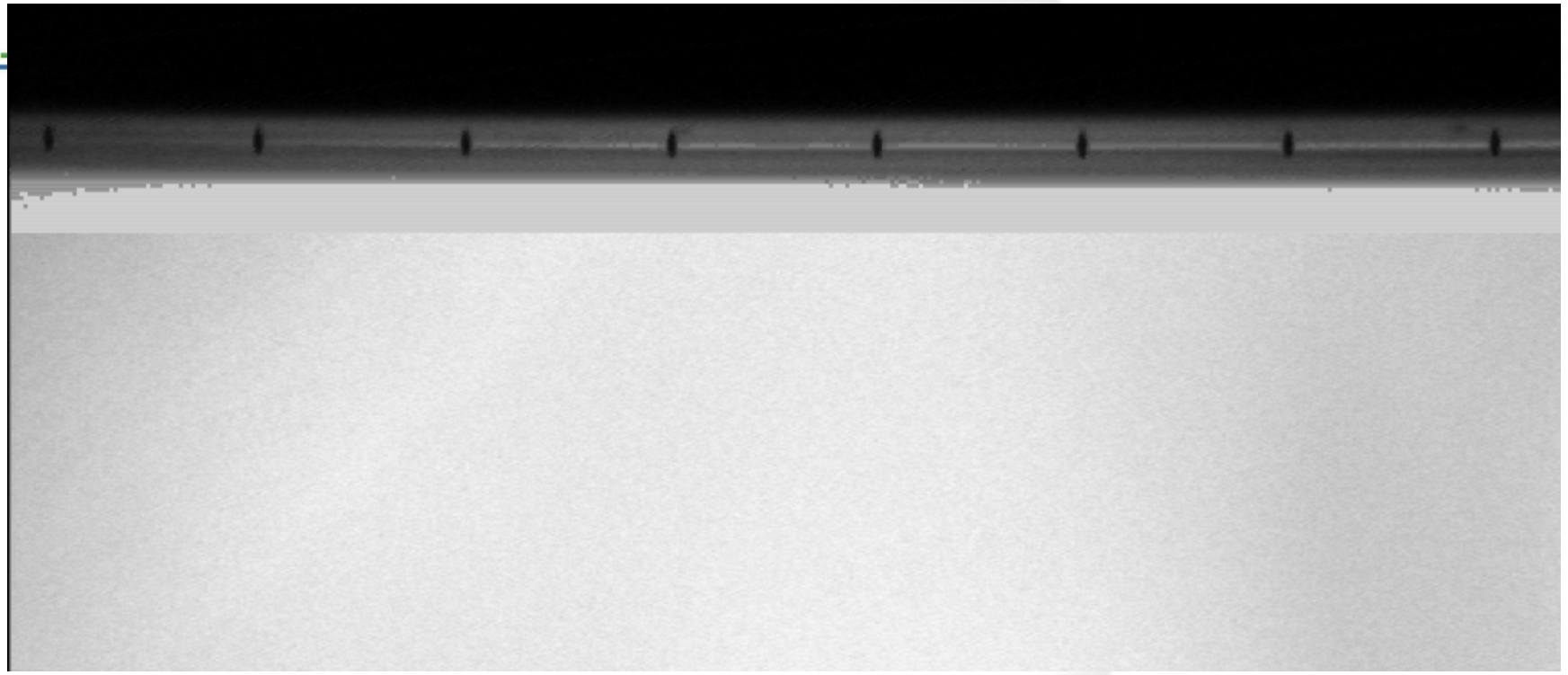
Ink Jets in Action



Precise deposition of material only where it is needed

Productivity is a function of the number of nozzles used

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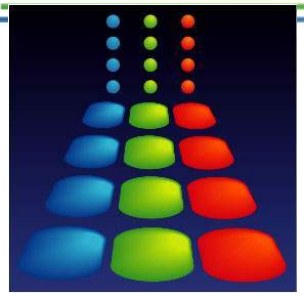
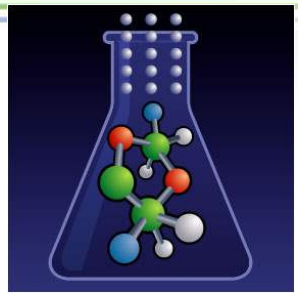
Materials Deposition Markets



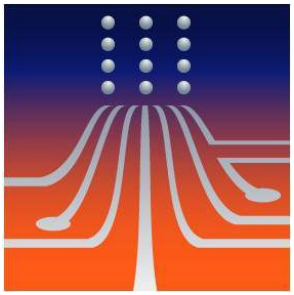
Displays

- Flat Panel Displays
- PLED
- LCD
- Color Filters
- Display Backplanes
- Flexible Displays



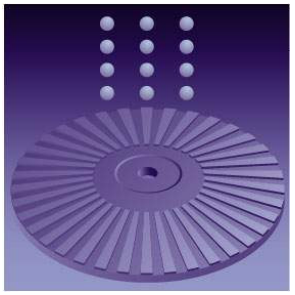
Chemical

- Material Development
- Substrate Development
- Coatings



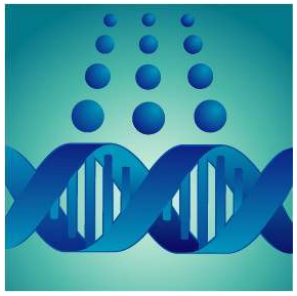
Electronics

- Flex Circuits
- RFID
- PCB Photomasks
- Wearable Electronics
- Solar
- Fuel Cells
- Batteries



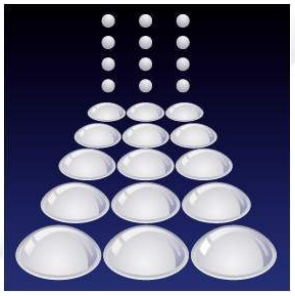
3D Mechanical

- 3D Assembly Systems
- Sensing



Life Science

- DNA
- Proteomics
- Antibodies
- Food Science
- Pathogen Detection
- Medical Devices



Optical

- Optical Lenses
- Light Pipes

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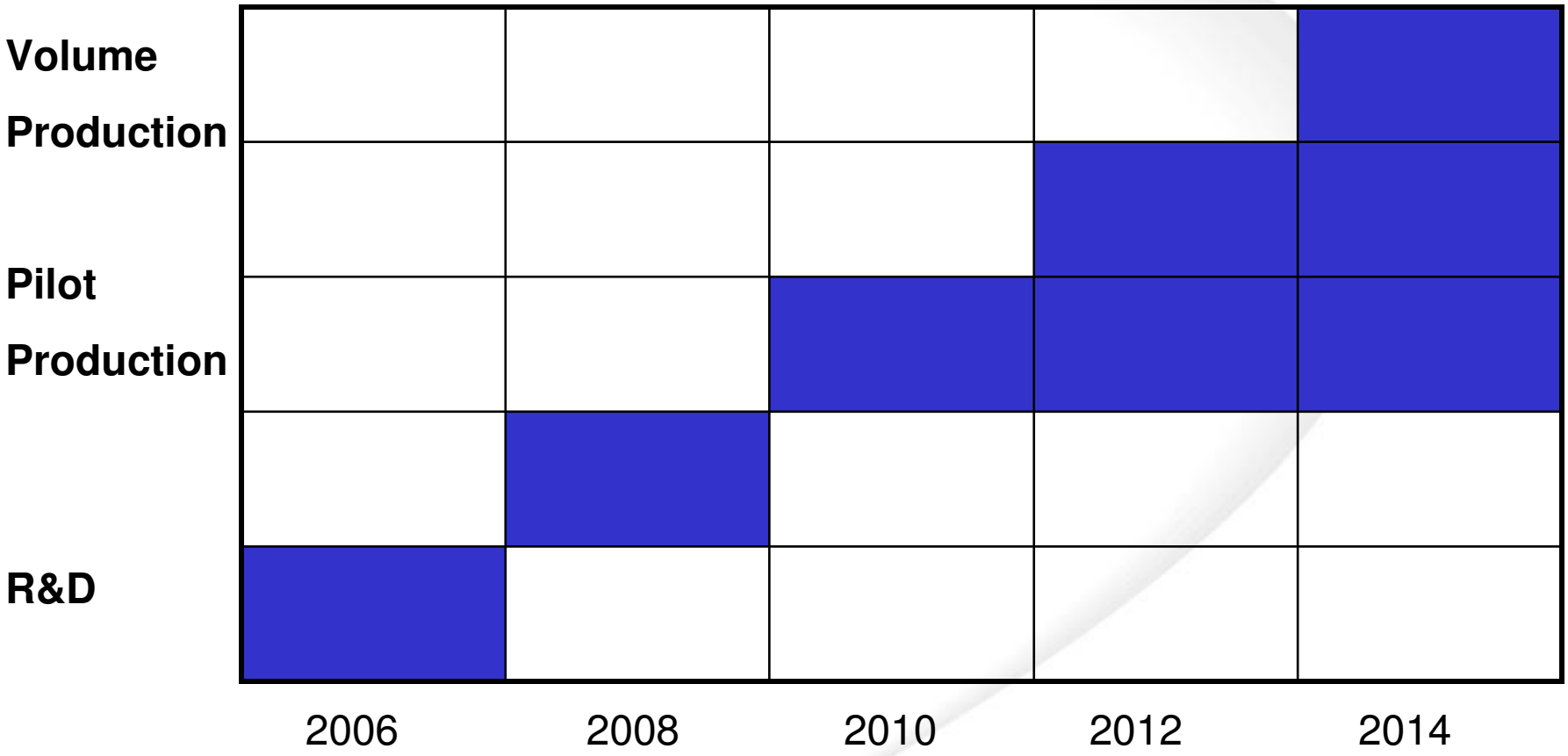
Market Potential for Ink Jet Manufacturing: Printed Electronics



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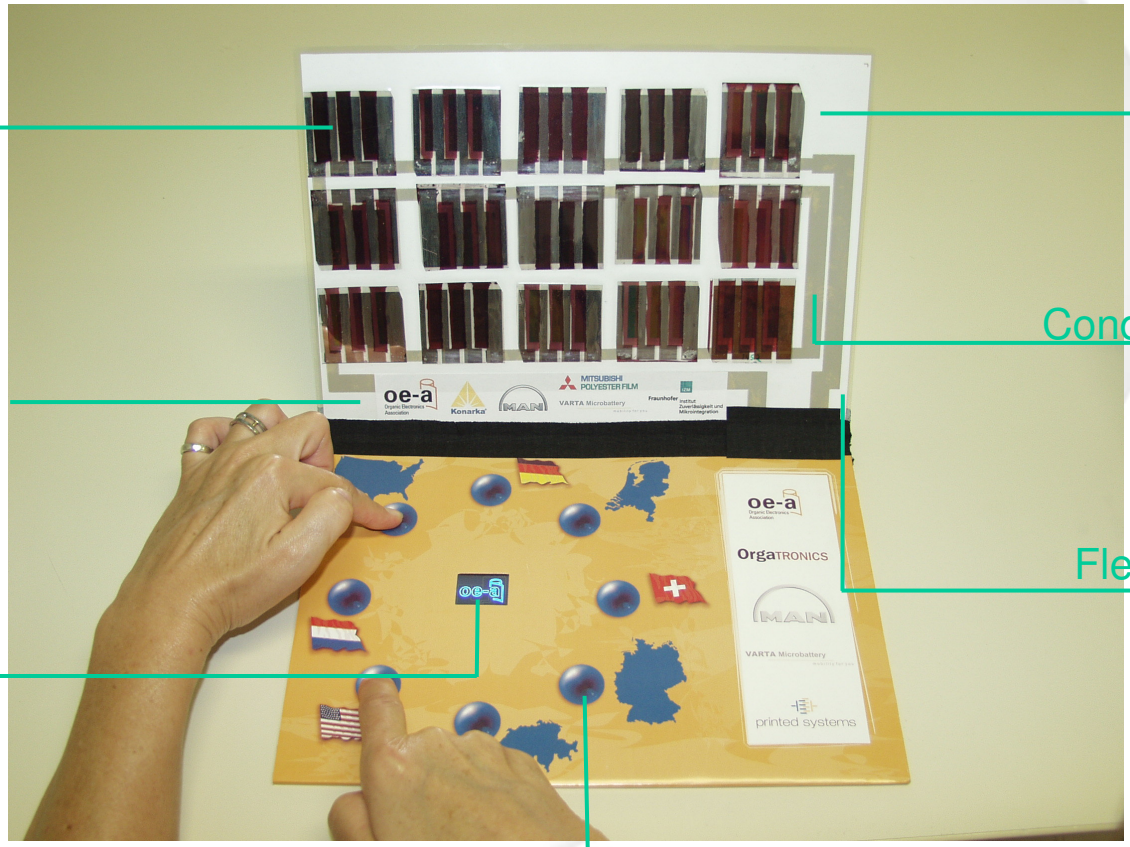
World-wide Focus on Printed Electronics: OE-A Game Board Demonstrator (1st Version)



photovoltaic cell

Konarka

film substrate

MITSUBISHI POLYESTER FILM

Conducting patterns

MAN

system integration

Fraunhofer IZM Institut Zuverlässigkeit und Mikrointegration

Flexible microbattery

VARTA Microbattery mobility for you

OLED-display

OrgaTRONICS

keyboard

printed systems

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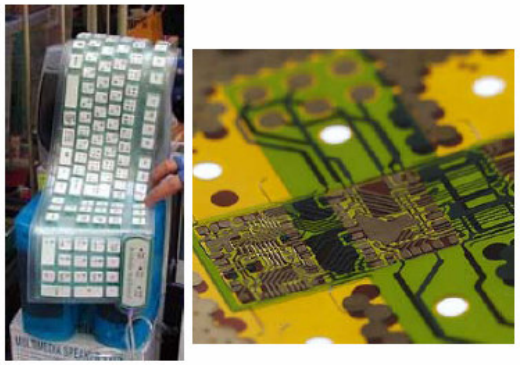
More Manufacturing Opportunities for Ink Jets

- Printed Circuit Boards (PCB) & Traditional Electronics
  - Etch Mask
  - Solder Mask
  - Legend
  - Conductive Traces
  - Solder Interconnects
  - Adhesives
  - Micro-optics
  - Embedded Resistors, Inductor and Capacitors
  - Batteries
  - Photovoltaics



Other examples of flexible electronics applications

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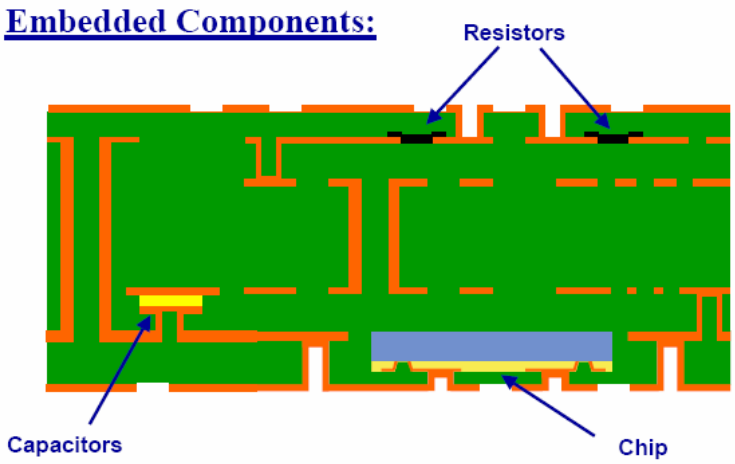
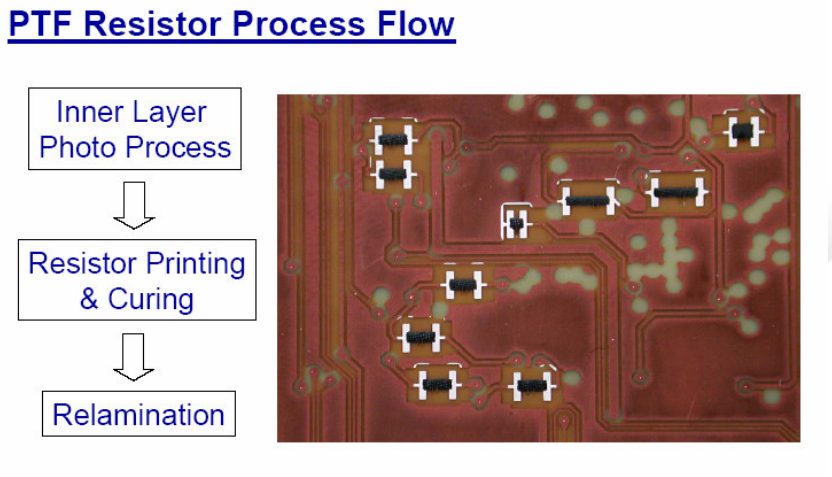
PCB Embedded Components





Courtesy AT&S, Austria

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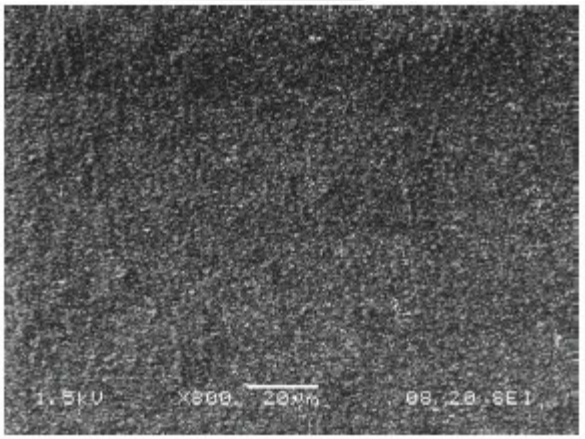
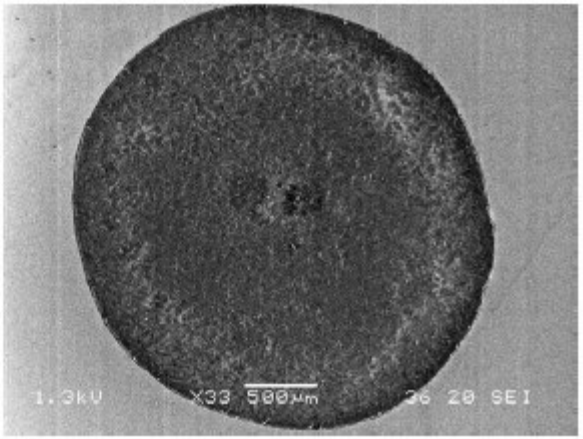
Jettable PCB Fluids Are Key to Manufacturing Success

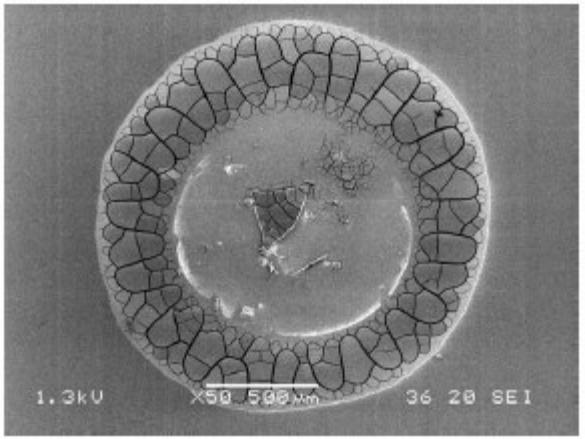
Mechanical Properties
- Hardness
- Adhesion

Morphology

Environmental Testing







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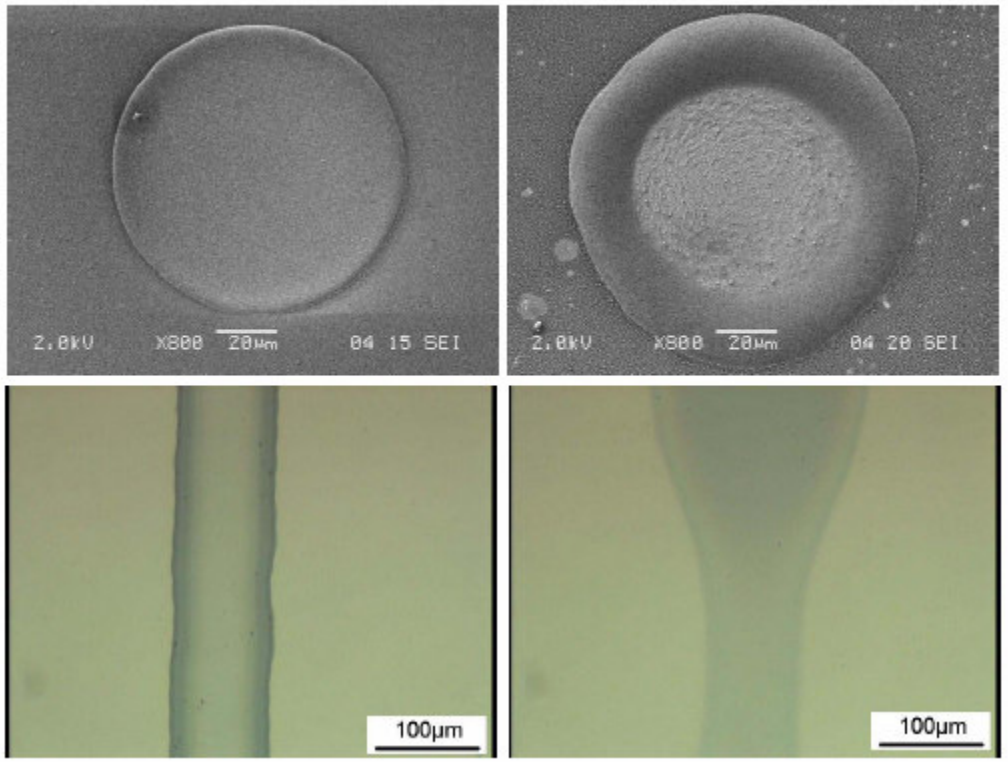
PCB Quality Requirements

Print Quality – Droplet formation and Line formation



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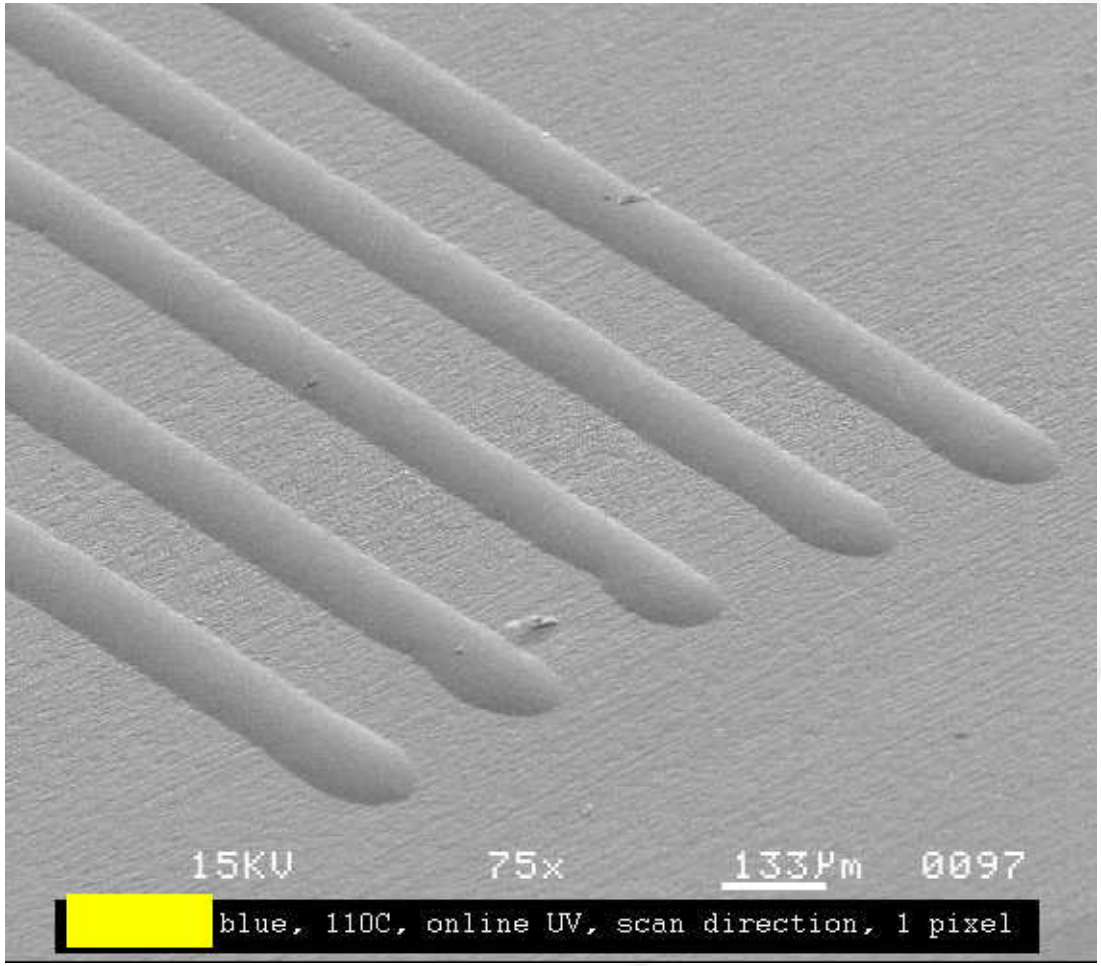
Jetted Solder Resist



- 30 pL Drops
- UV-Cured Resist by Rohm&Haas EM

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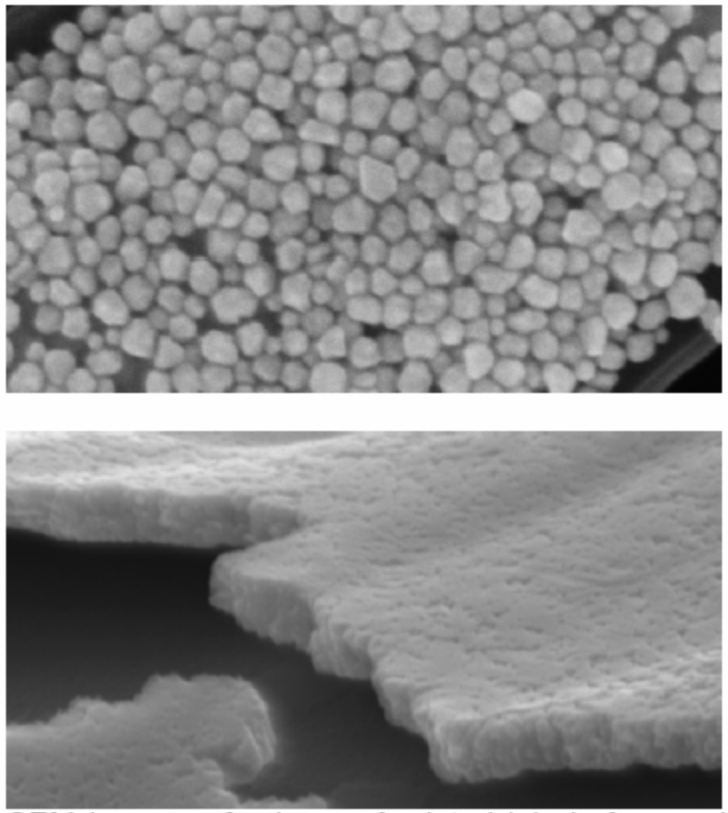
Nano Particle Conductive Silver



SEM images of a layer of printed ink, before and after a 10 min cure at 180 ºC

Courtesy Cabot/SMP

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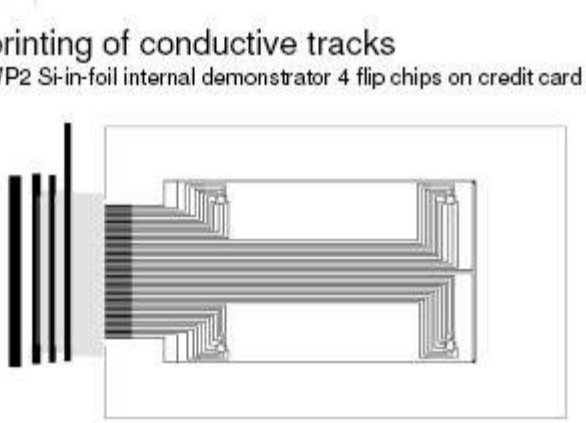
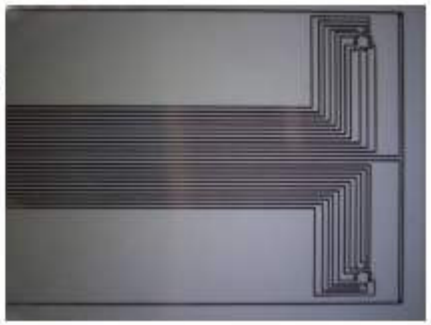
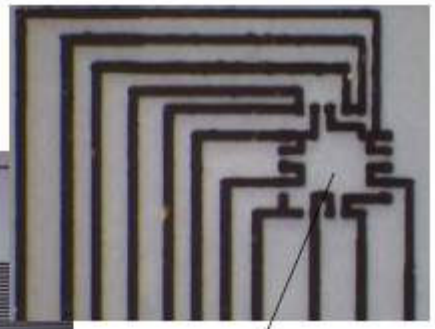
DMP working at Holst Centre

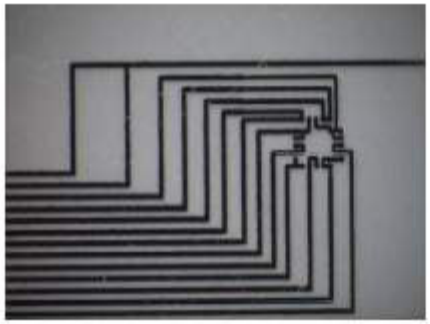
Holst Centre

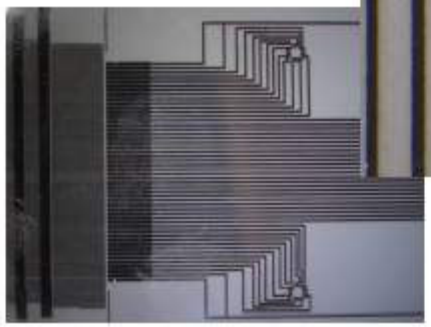
Inkjet printing of conductive tracks
(for TP3-WP2 Si-in-foil internal demonstrator 4 flip chips on credit card size PEN foil)











chip pad size: 2.3 x 2.3 mm

tracks width: 100 µm

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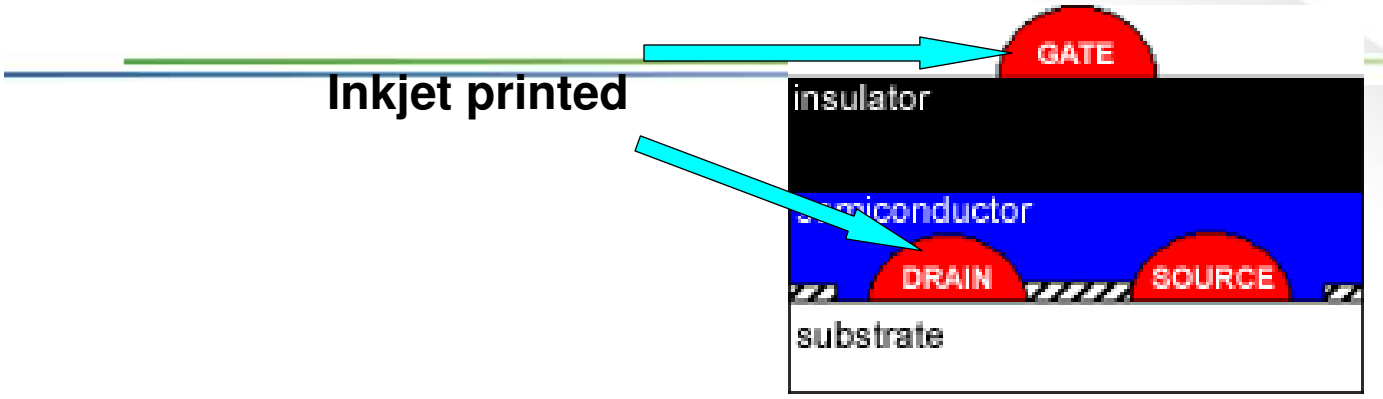
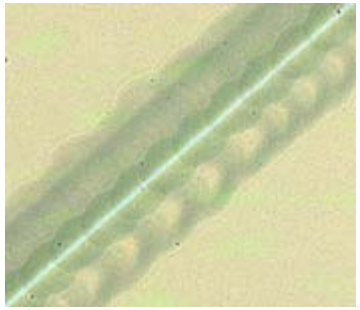
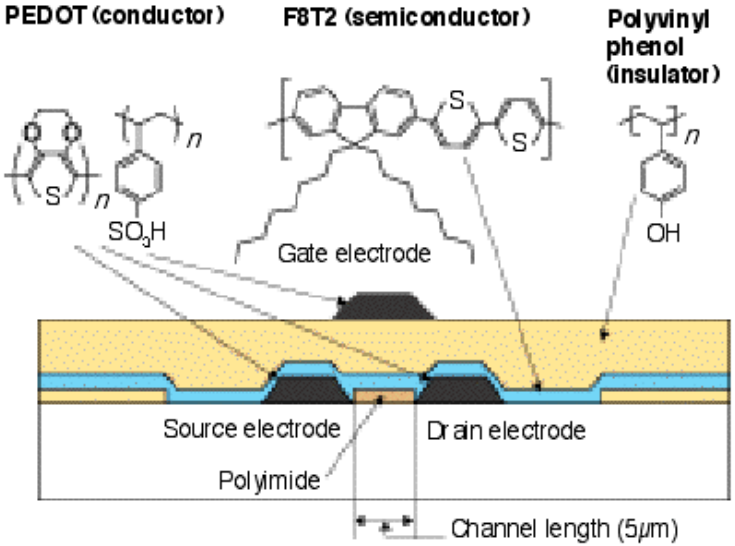
Ink Jet Printed OSC Transistors



Plastic Logic inkjet printed TFT





Epson prototype transistor
PEDOT is inkjet applied

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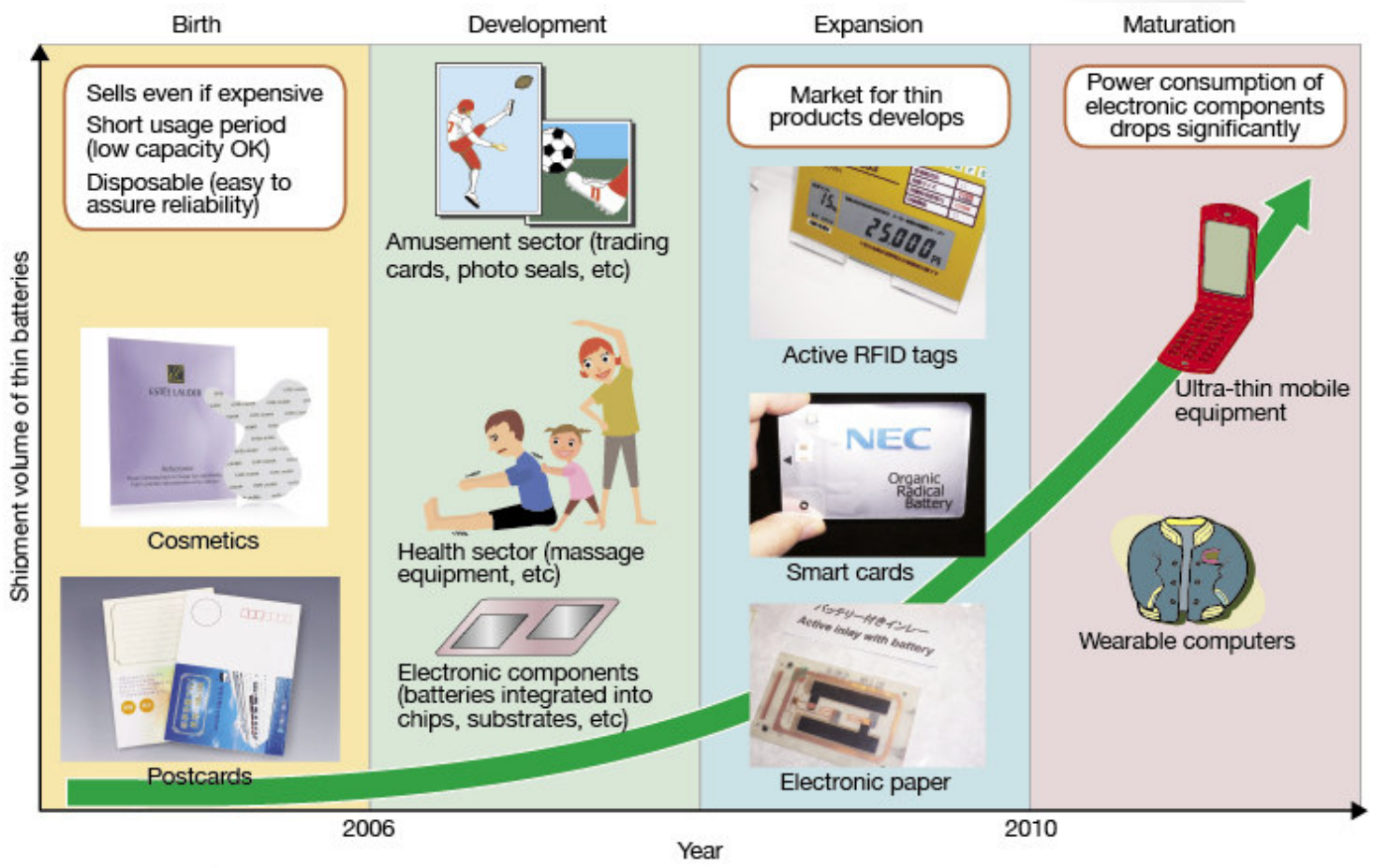
Product Development Cycle



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Manufacturing Equipment: IJP Polyimide Coater System

ISHII HYOKI
Ishii Hyoki Co.,Ltd.

IJP PI Coater System

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Advantages of Ink Jets in Manufacturing LCD Alignment layer

- Replaces flexo printing of polyimide solution
- Ink jet is additive:
  - Saves ~ 200K$ fluid/machine per year
  - Ink jet production polyimide coater costs 50% of flexo system

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Manufacturing Equipment: Litrex Corporation

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RGB Color Filters via Ink Jets

- LCD color filters are large % of total panel cost
- Ink jet technology provides cost reductions up to 40%
- Material usage reduced 20-30%
- Investment cost reductions > 50%
- Environmentally friendly
- High volume production planned for 2007

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Before Manufacturing: Jetting Functional Fluids in the Lab

- Provide cost-effective ink jet system for formulating functional fluids
- Provide cost-effective ink jet system for process development and improvement
- Provide an easy-to-use system that is scalable from lab to production

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Dimatix Materials Printer (DMP)

- Enables evaluation of fluids
  - Conductivity and resolution for antenna
  - Feature definition and performance for organic electronics
- Enables process development
  - Cure cycles for plastic substrates
  - Evaluate drop spread vs. surface treatments
  - Evaluate fluid adhesion and robustness
- Generates samples

Easy to Use

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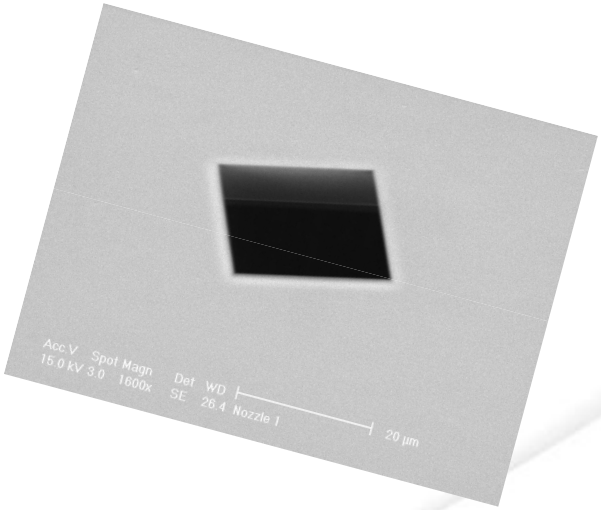
New Technology for Development and Manufacturing: Motivation

- Conductive traces for backplanes need to be ~ 20 microns
- Solar cell fabrication needs traces < 75 microns
- Organic TFTs need fine feature size
- 10 pL drops
  - 40-100 micron line width depending on fluid, substrate, and drop frequency

FUJIFILM Dimatix Announces
1 Picoliter Ink Jet Products!

- Smallest drop size for production
- Fully integrated MEMS process
- Wide fluid compatibility
- 16-jet cartridges for Dimatix Materials Printer



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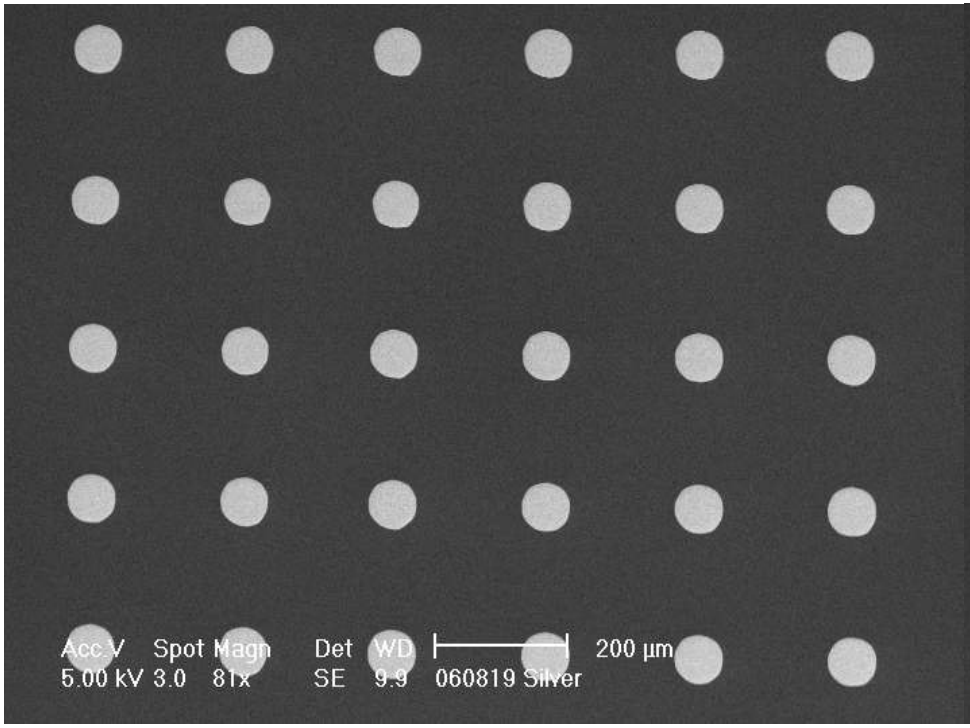
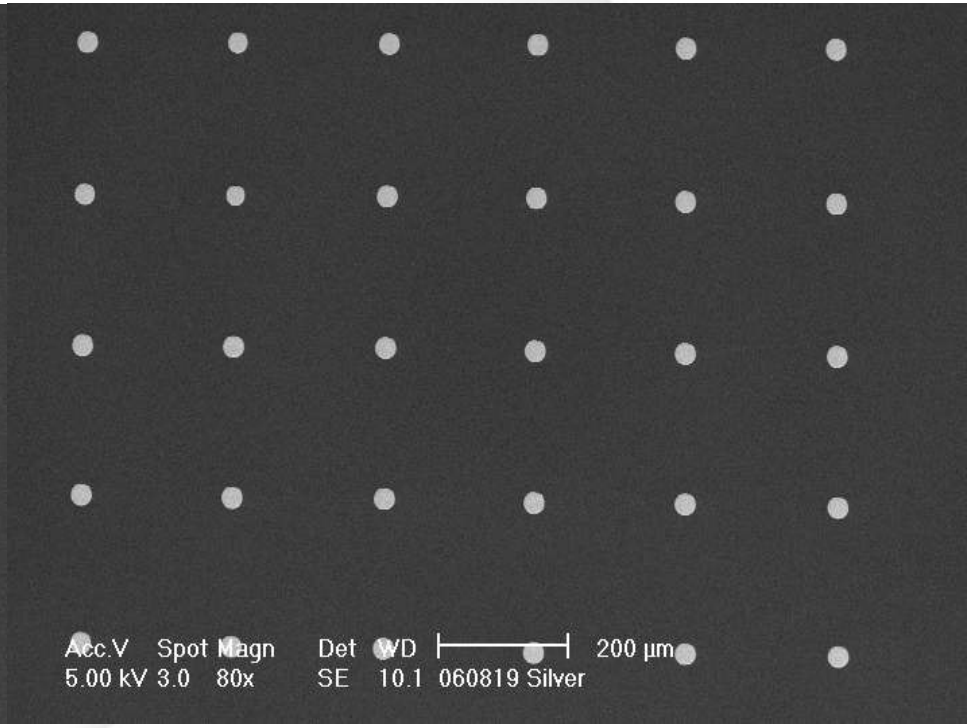
10 and 1 Picoliter Drops on Si Wafer

10 pl



1 pl



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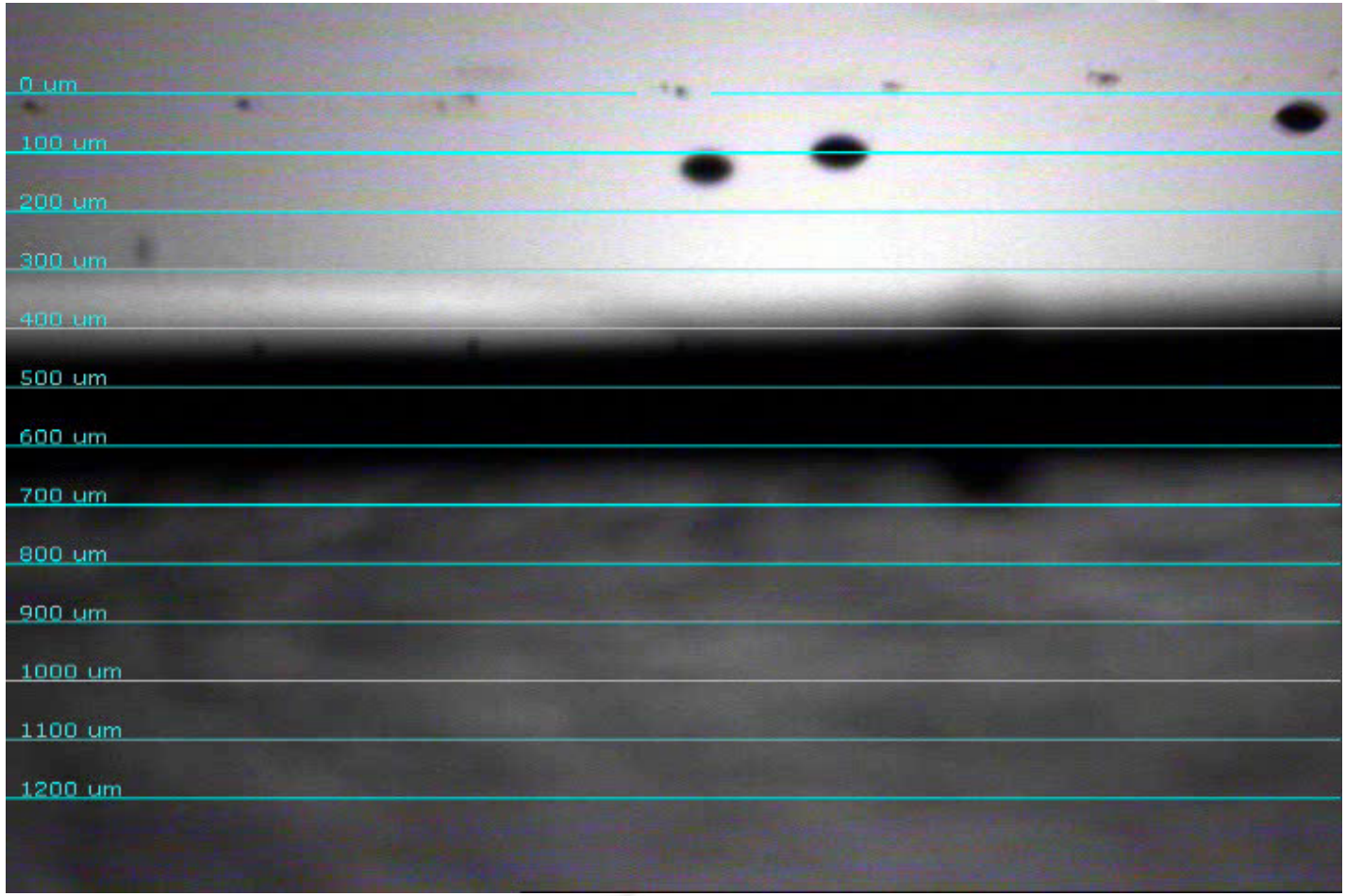
1 pL Jetting with DMP



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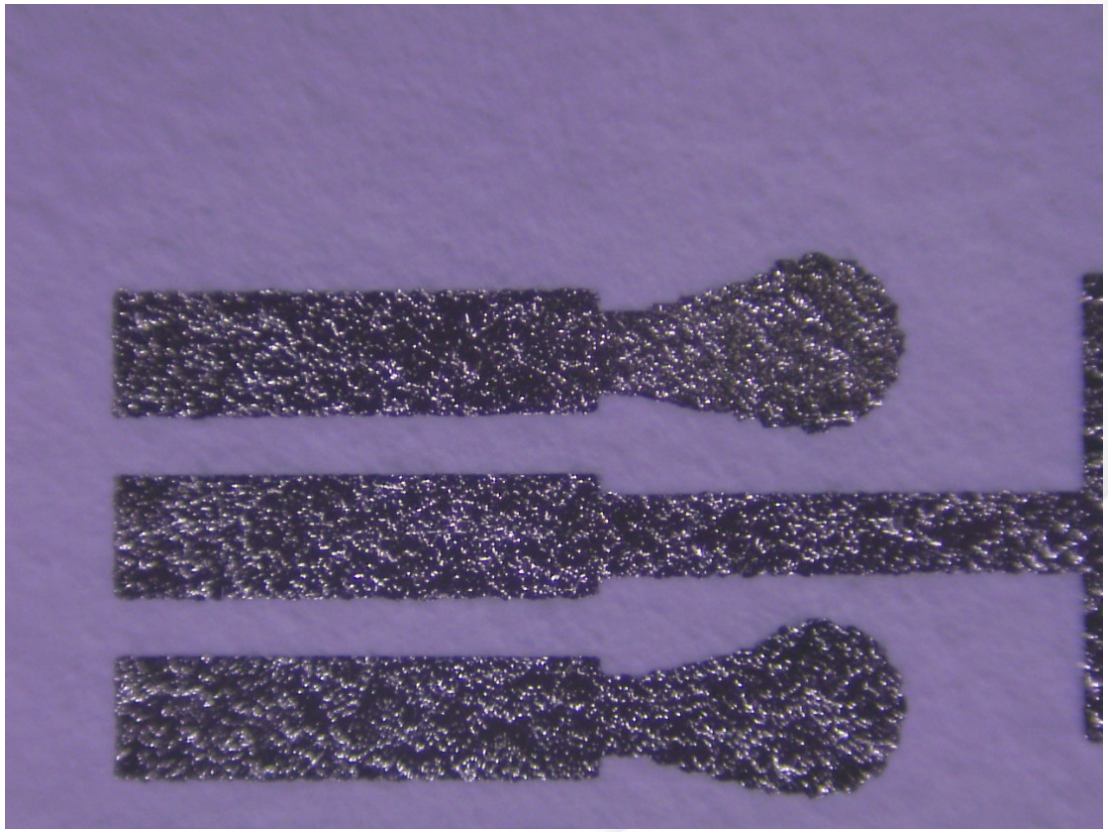
Conductive Silver on Teslin : Printed with 1 pL DMP Cartridge



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Future Directions for Ink Jet Manufacturing

Line width

	Today	2-5 years	>5 years
Laboratory	25um	10um	5um
Pilot Production	50um	20um	5um
High Volume Production	70um	25um	10um

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New Products Essential for Materials Deposition Revenue Growth

- 128 jet printhead
  - Enables customers to move to pilot production based on initial results from DMP
  - Basic element for stacked printheads or printhead array
- Stacked printhead
  - Enables customers to achieve production throughput in a scanning system
- Printhead array
  - Enables customers to achieve production throughput in a single pass system

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Conclusions: Ink Jets are Proving Valuable Tools for Materials Deposition

- NOW:
  - Ink jets incorporated into commercial FPD manufacturing equipment
  - Ink jets in pilot manufacturing organic electronics
  - R&D materials deposition printer available (DMP)
- FUTURE:
  - Smaller features
  - Higher productivity
  - New opportunities

- Polymer solar film
- Flexible polymer-based lighting
- Electronic books
- Printed polymer backplanes
- Transparent solar cells
- Flexible electronics and batteries
- Paper-like products
- Disposable diagnostic devices
- Intelligent packaging
- Large area electronics

QUESTIONS?

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